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Scintillator tests for SpecMAT

J. A. Swartz

ACTAR TPC Collaboration Workshop
GANIL, Caen
19/11/2015

Contents

Co-authors:

KU Leuven - IKS: R.Raabe, H. De Witte, F. Renzi, T. Marchi

University of York: D. Jenkins, N.S. Bondili, P. Joshi

GANIL: G.F. Grinyer

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The SpecMAT project:

To investigate exotic nuclei, specifically

- neutron-rich around **Z = 28**, e.g. $^{68,\,70}$Ni; $^{78,\,80}$Zn (*d*,*p*); (*d*,^{3}He)
- neutron-deficient around **Z = 82**, e.g. ^{184}Hg, ^{188}Pb, ^{196}Po (*d*,*p*); (*p*,*d*)
  - To place active target detector inside solenoid magnet,
  - & supplement with scintillator array in B-field...

Direct transfer reactions possible in this region with 5 – 10 MeV/u beams from HIE-ISOLDE

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  - To place **active target** detector inside **solenoid magnet**,
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Direct transfer reactions possible in this region with 5 – 10 MeV/u beams from HIE-ISOLDE

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$LaBr_3(Ce)$ scintillators

Internal contamination problems due to Lanthanum

Density = **5.07 g/cm^3**

Patented by Saint Gobain (though also sold through Canberra, Ortec..)

Price ~ **9 000 EUR** per scintillator for 1.5"*1.5" cylindrical model

Resolution = **2.7-3.3%** @ 662 keV

$CeBr_3$ scintillators

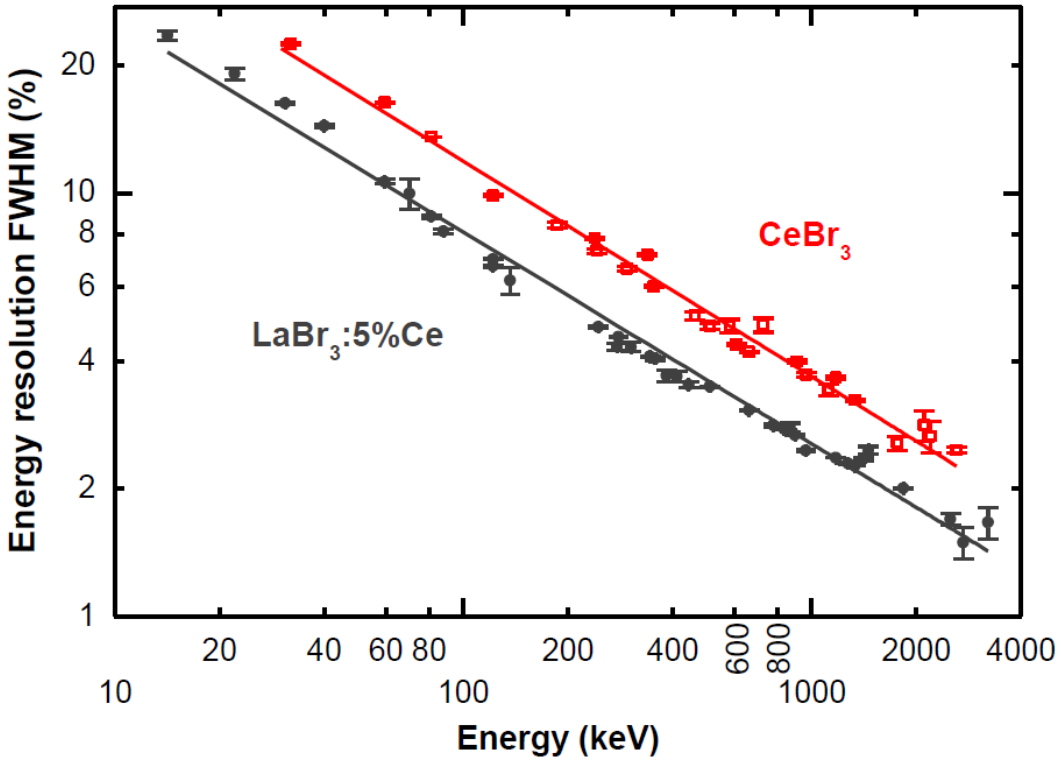
No internal background (apart from ^{227}Ac contamination)

Density = **5.19 g/cm^3**

Produced by Scionix Holland, RMD, Kinheng Crystal..

Price ~ **4 500 EUR** per scintillator for 1.5"*1.5" cylindrical model

Resolution = **3.8-4.0%** @ 662 keV



F.G.A. Quarati *et al.*, NIM A 729 (2013) 596-604

Cylindrical prototypes tested at Leuven with PMTs:

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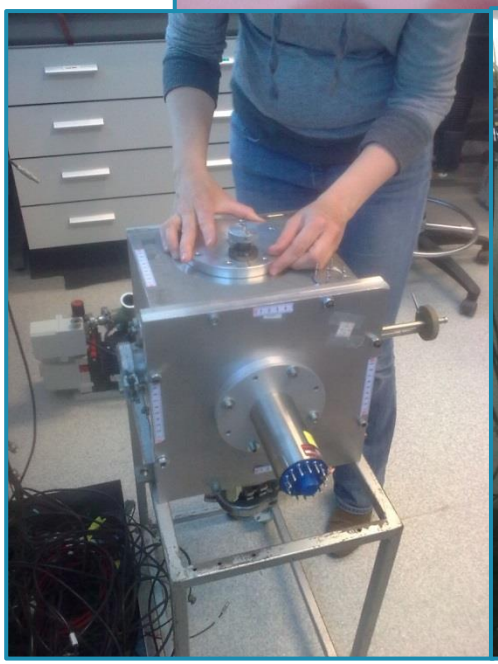
$CeBr_3$

- 1.5"×1.5"
- 2"×2"

$LaBr_3$

- 1.5"×1.5"



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- Problem with scintillators + conventional PMTs:
- Detectors need to work in high B-field...

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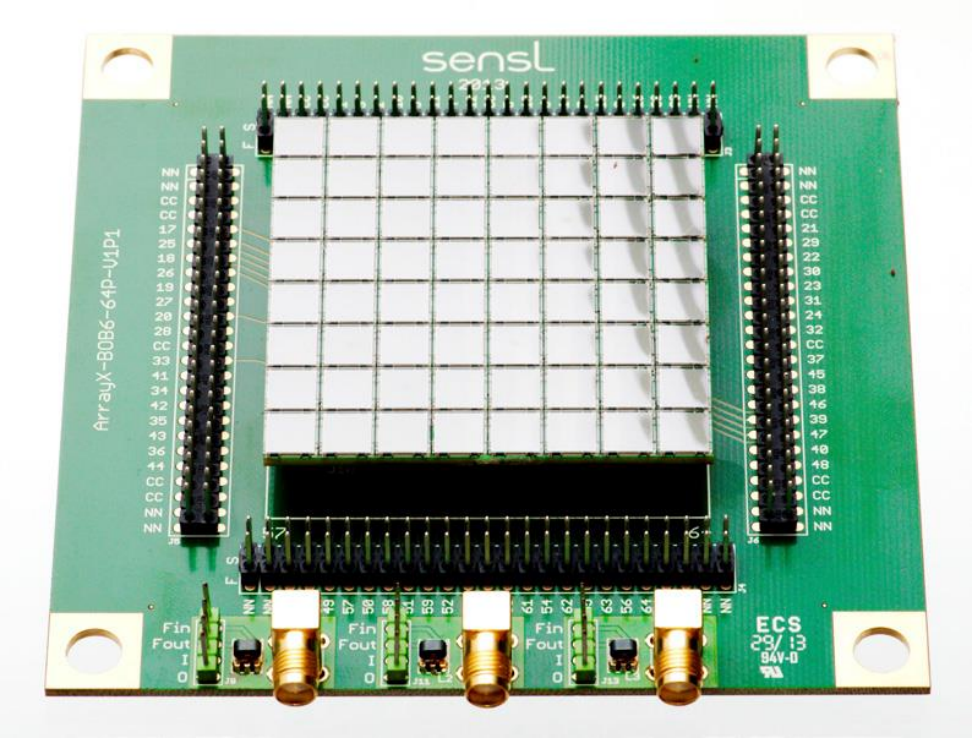
- Detectors need to work in high B-field...
- Solution: replace PMTs with **Silicon Photomultipliers** (SiPMs)



Array-SMT User Manual – SensL, *www.sensl.com/downloads/ds/UM-**ArraySMT**.pdf*

$LaBr_3(Ce)$ – tested at University of York Industrial applications lab

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Coupled 51x51x51 mm $LaBr_3$ to 8x8 array of 6 mm SiPMs

Optimized Voltage (29 to 30 V) and shaping time (0.5 µs)

SensL PCB

$LaBr_3$ crystal with SiPMs

Crystal on PCB

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SiPM data, J.A. Swartz, D. Jenkins, N.S. Bondili and P. Joshi

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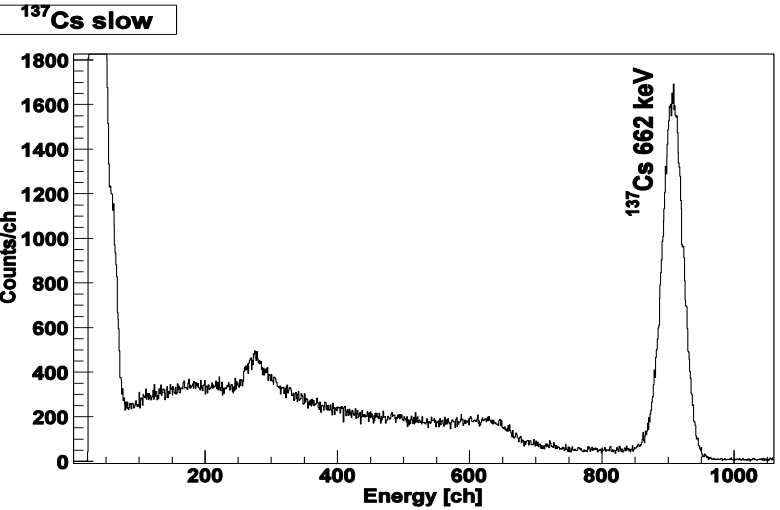

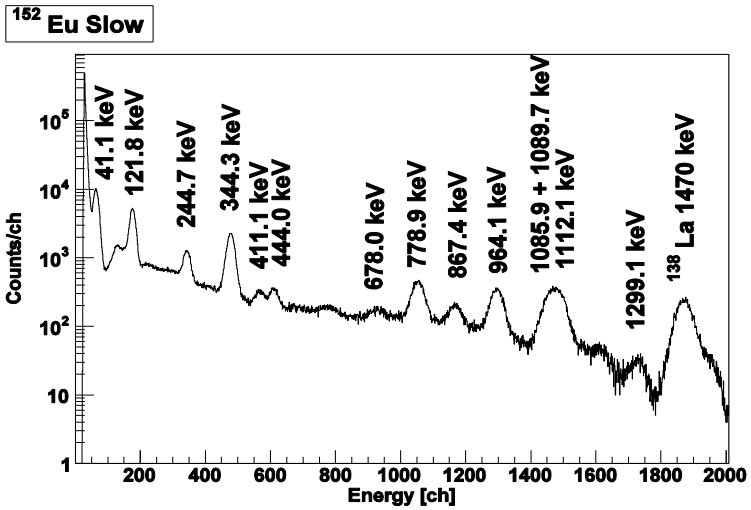

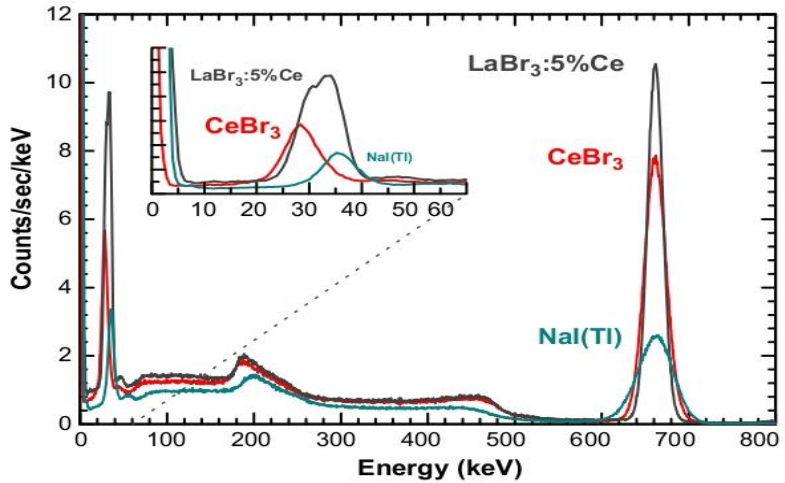

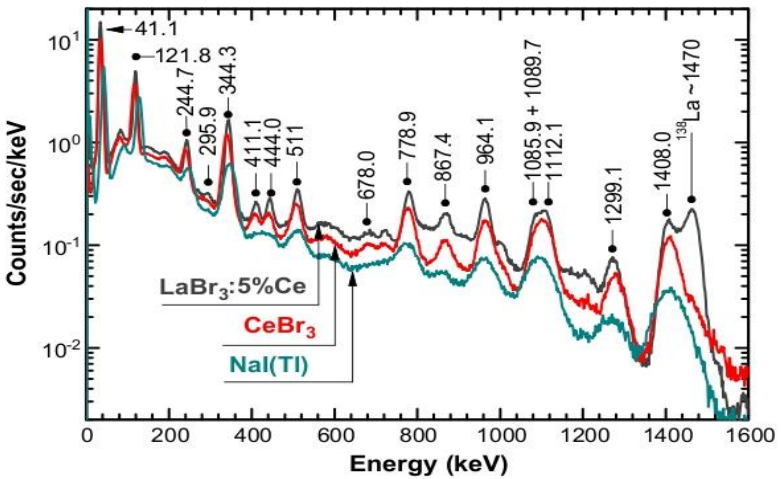

2×2“ cubic crystal data obtained with SiPM and $LaBr_3$ (top),

and PM tube + $LaBr_3$ CeBr, NaI (bottom, F. Quarati *et al*. NIM A 729 (2013) 596-604)

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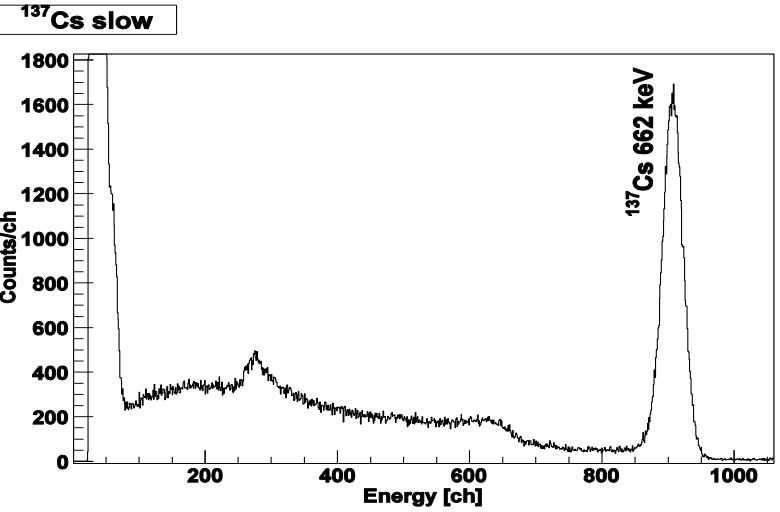
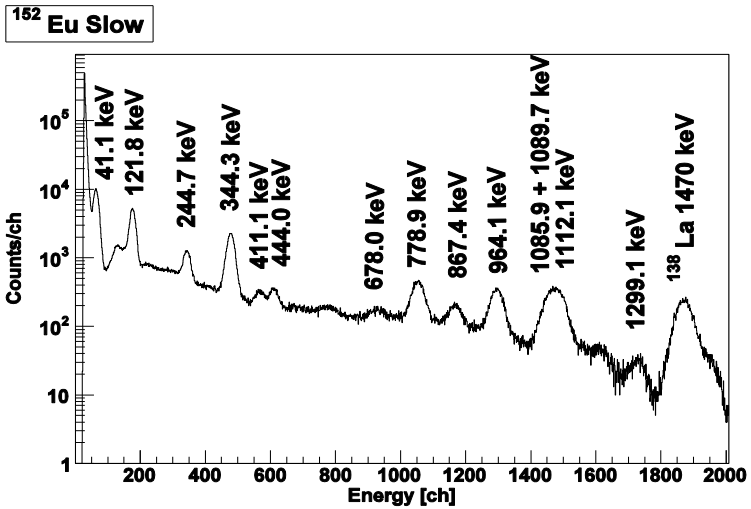
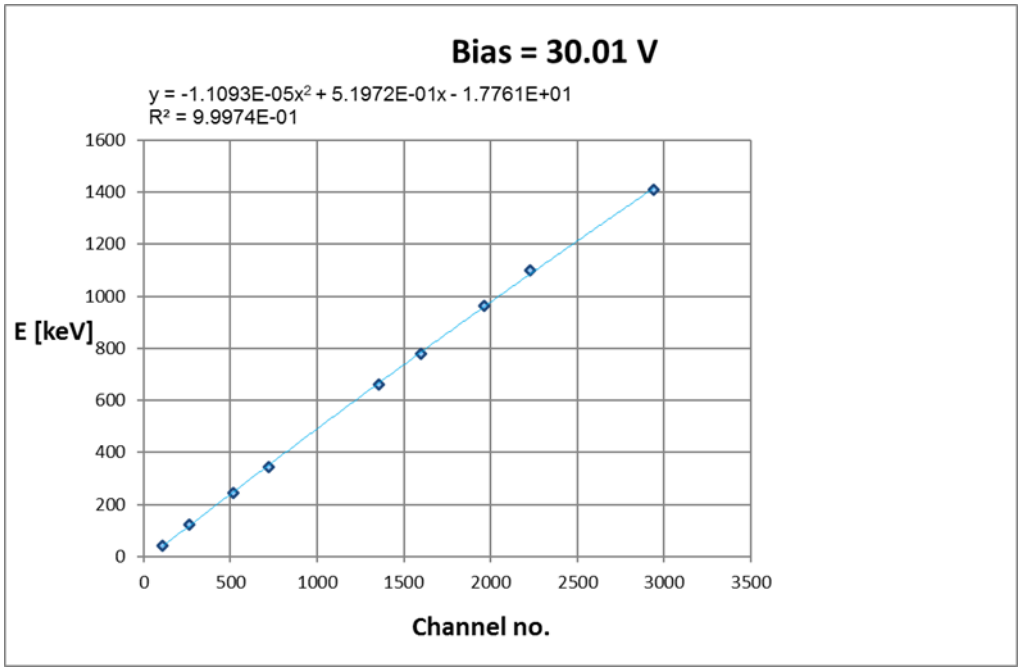
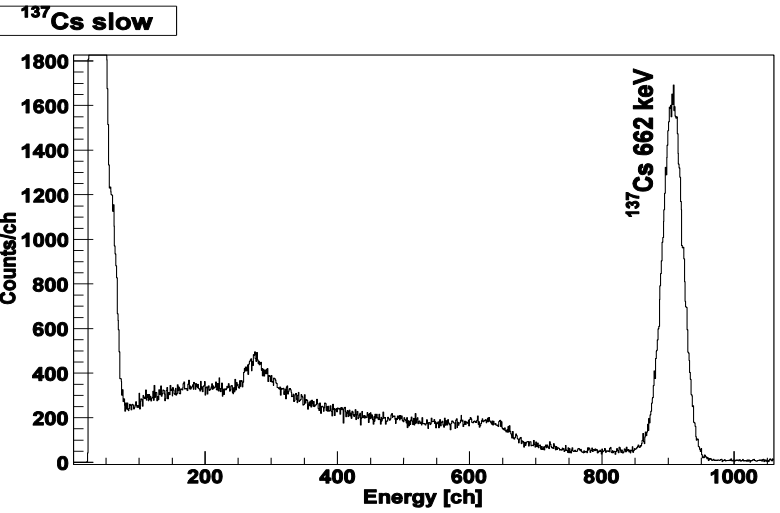
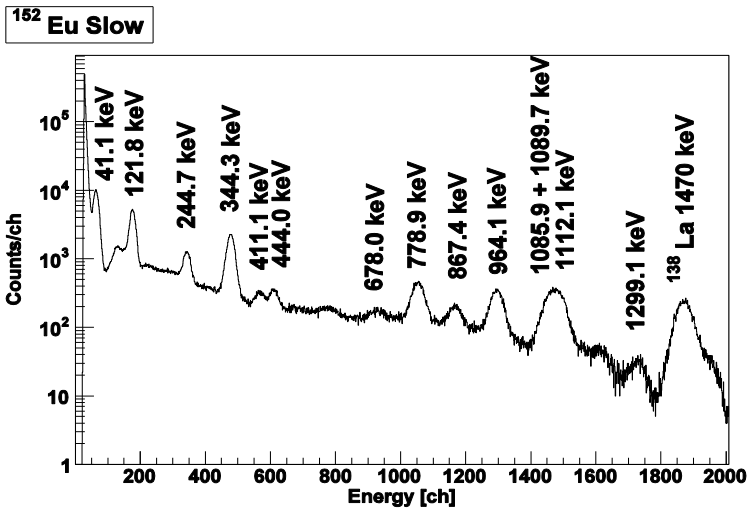


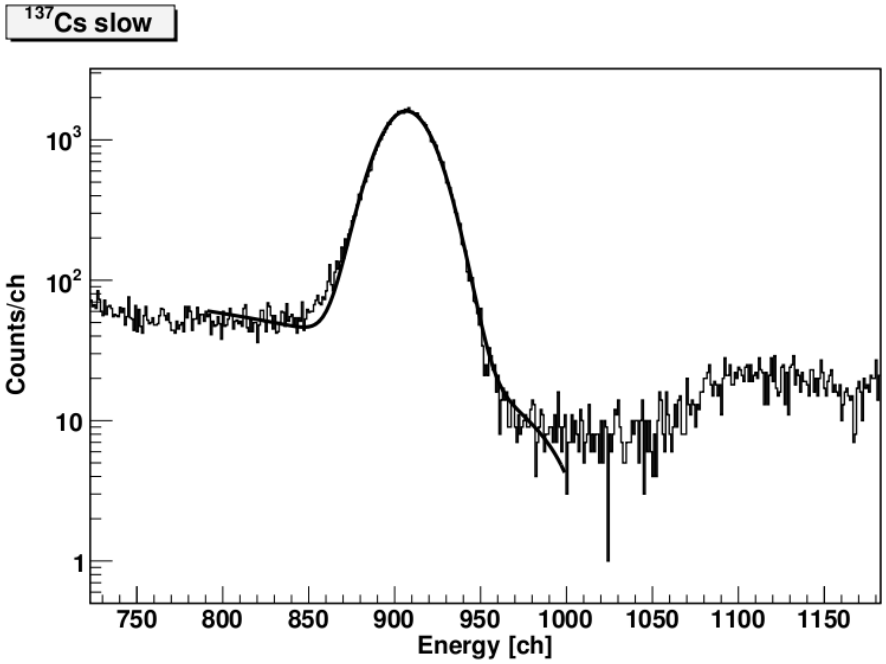




- Good linearity of energy to signal







- Good linearity of energy to signal
- Resolution from fit, FWHM = 4.0% at 662 keV. After correction for non-linearity, FWHM = **4.2%**

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PMT data (red), H. De Witte and J.A. Swartz

PMT data (green), F.G.A. Quarati *et al.*, NIM A 729 (2013) 596-604

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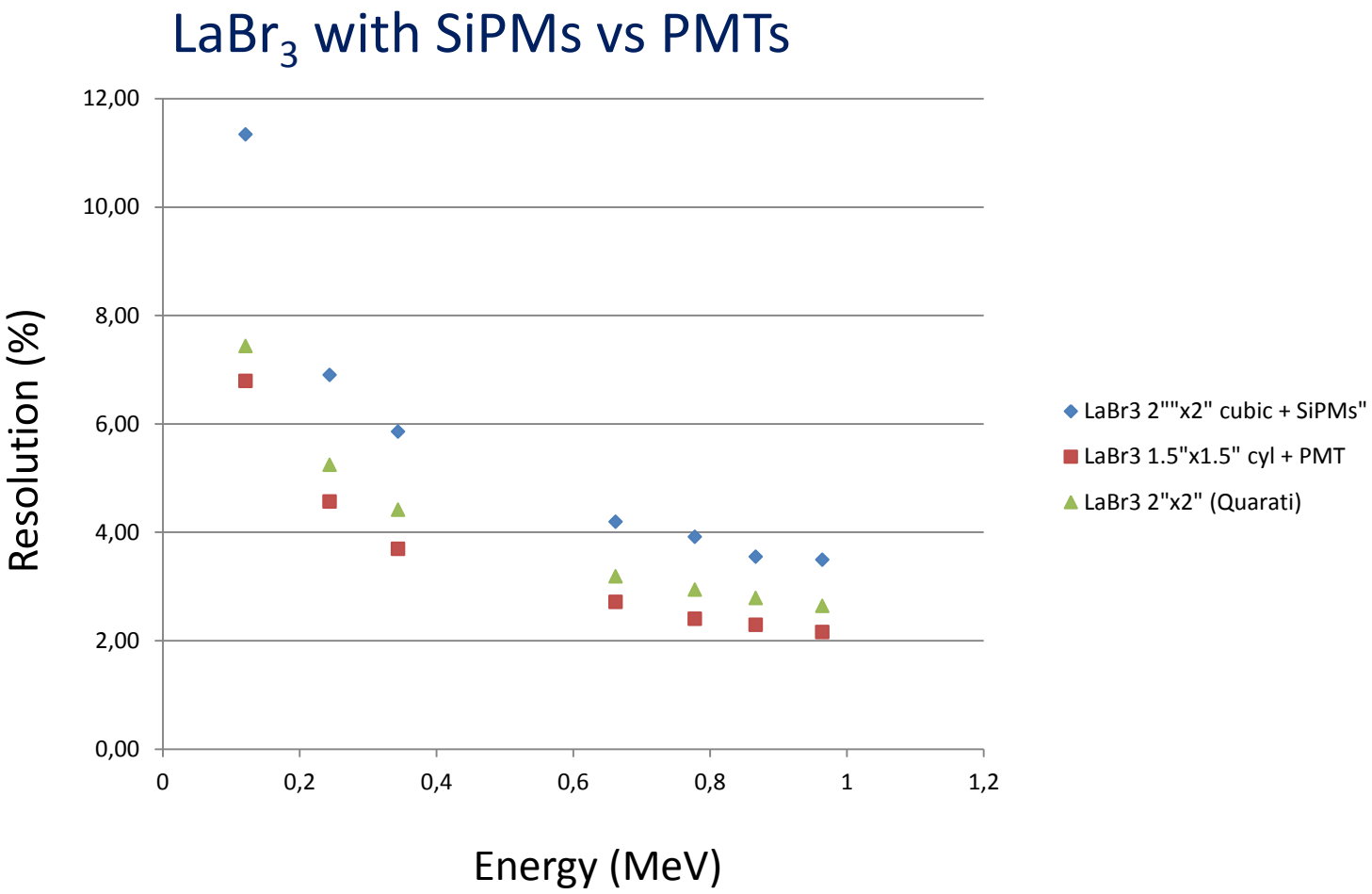

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Tests to couple scintillators to GET electronics:

- Used Hamamatsu PMT, and
- Scintipack PMT base + HV source from ORTEC.
- Coupled to reduced CoBo setup at GANIL

Electronics

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$CeBr_3$ PMT

HV = 600 V

PMT base & HV source
ORTEC Scintipack 296

Anode or Test

AsAd

Preamp

Lin Fan
Lecroy 428

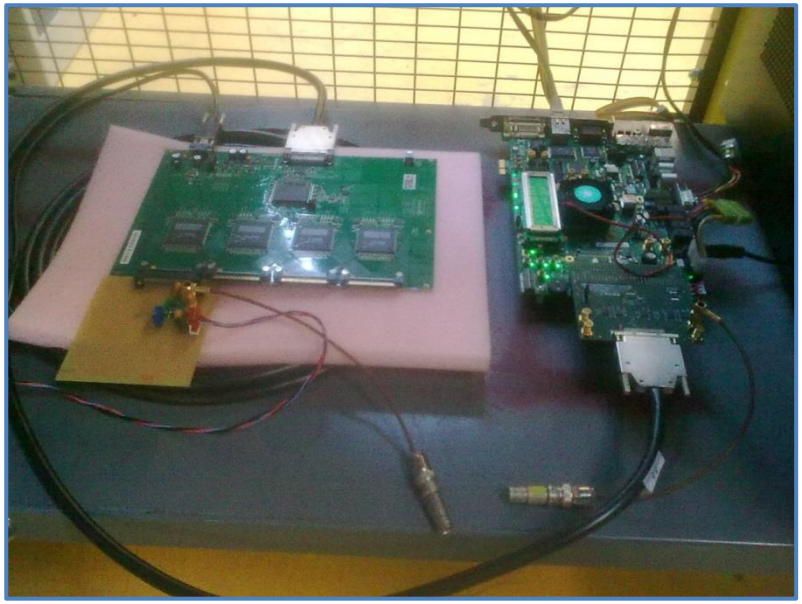
Fast amp
ORTEC FTA 820

Disc
Caen N845

Gate Gen
Lecroy 222

NIM/TTL

CoBo



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PMT + GET data, J.A. Swartz and G.F. Grinyer

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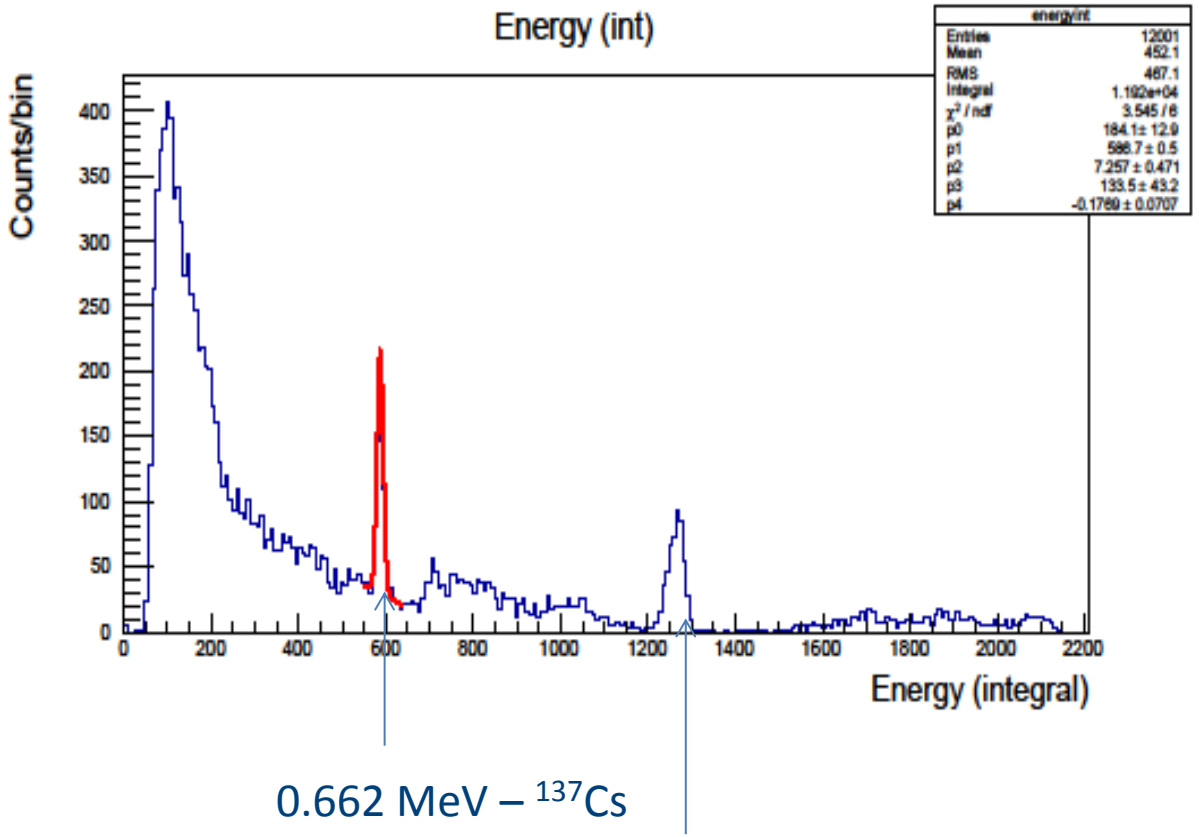
Preliminary data

Spectrum of ^{137}Cs with $LaBr_3$



0.662 MeV – ^{137}Cs

1.470 MeV – La bg

Resolution of FWHM = 3.1% at 662 keV, out of nominal 2.6%

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Preliminary data

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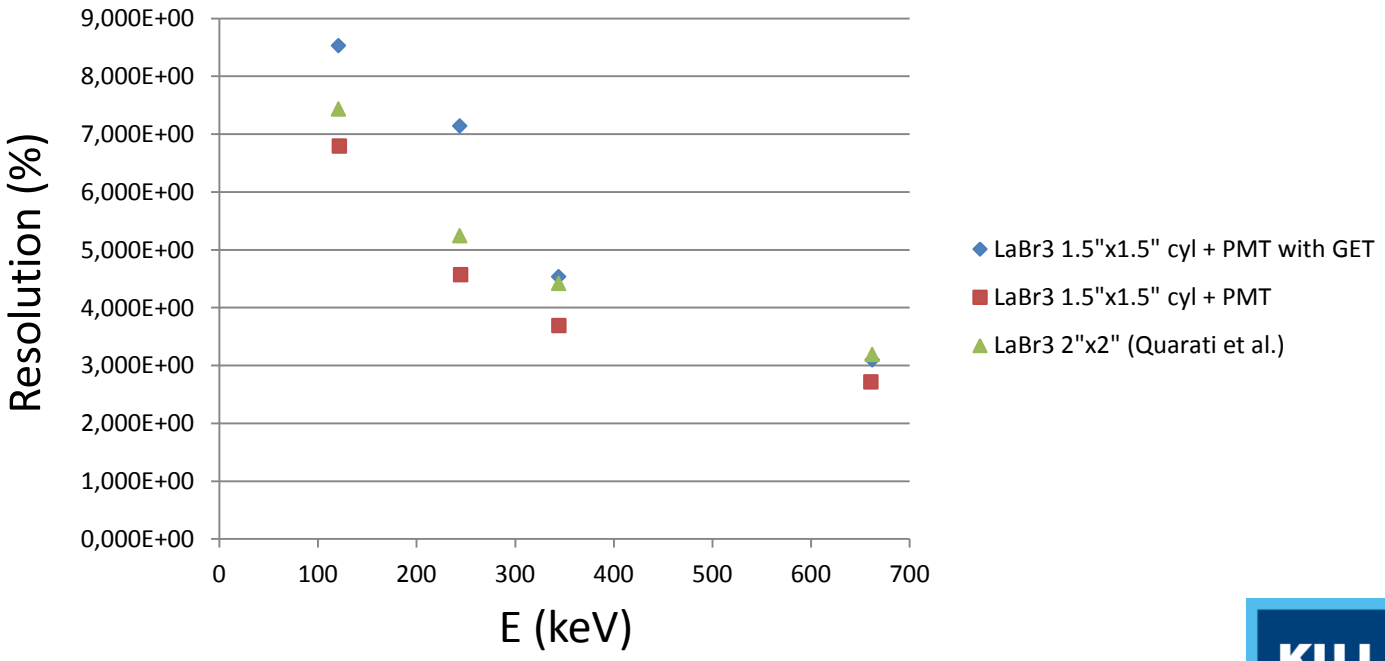
Best resolution values with GET vs nominal values

Material	Dimensions	GET	Nominal
LaBr3	1.5"x1.5"	3.1%	2.6%
CeBr3	1.5"x1.5"	5.7%	4.0%
CeBr3	2"x2"	5.5%	4.0%

LaBr3 + GET vs LaBr3



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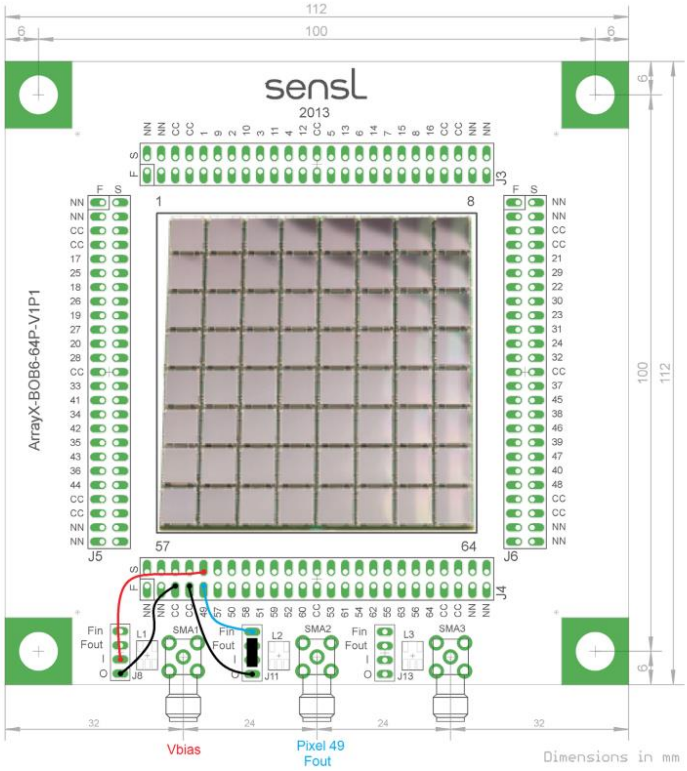
Last test data to be obtained:

- Need crystals with **SiPMs + GET** electronics
- Workshop at Leuven designed adaptor PCB board for inner 6*6 pixels of 8*8 pixel SiPM board



Connections for read-out of a single pixel.
(Array-SMT User Manual – SensL,
*www.sensl.com/downloads/ds/UM-**ArraySMT**.pdf*)

- To test this setup with 1.5"*1.5" cubic $LaBr_3$ & $CeBr_3$
- Setup then comes to GANIL for tests with GET

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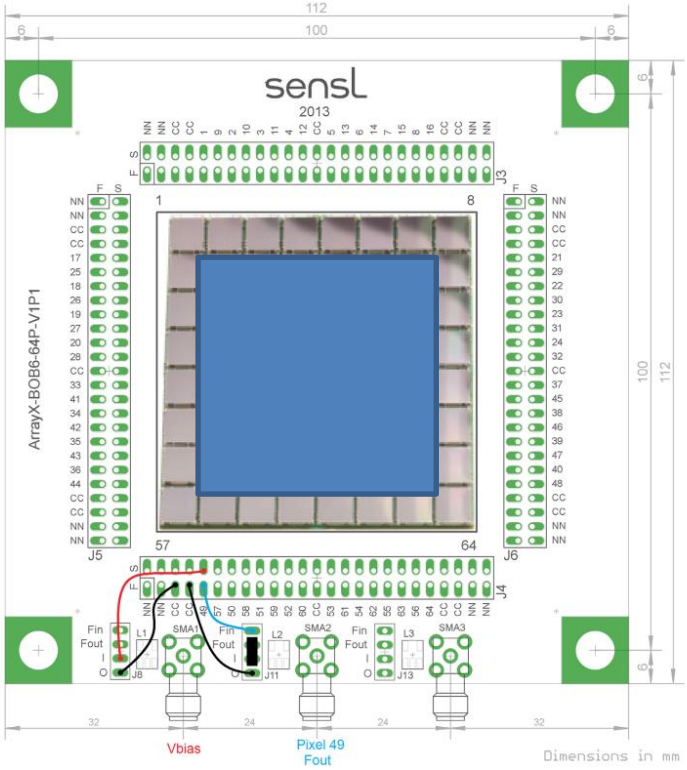

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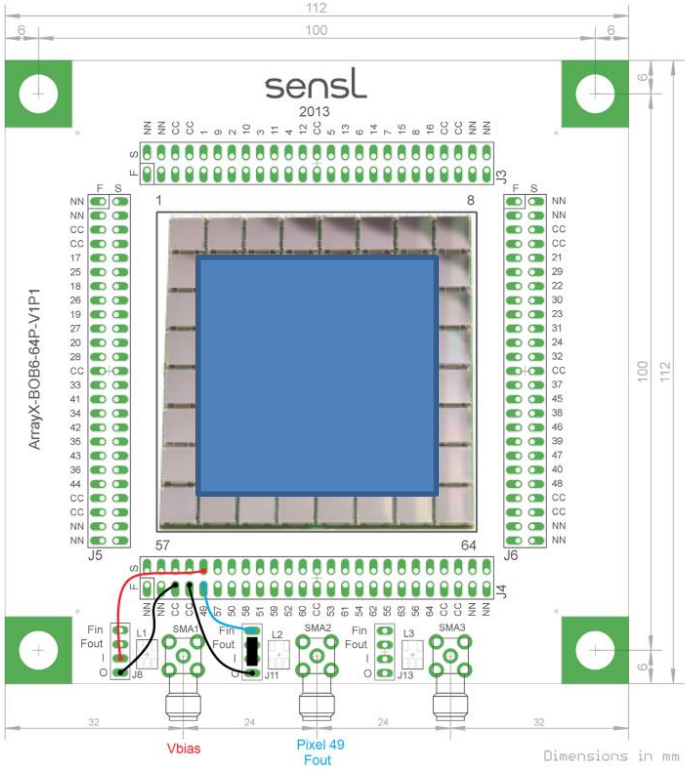

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- To test this setup with 1.5"*1.5" cubic $LaBr_3$ & $CeBr_3$
- Setup then comes to GANIL for tests with GET (circa Dec 2015)

SpecMAT – what is already measured:

- PMTs + Osprey module ($LaBr_3$ + $CeBr_3$)
- PMTs + GET ($LaBr_3$ + $CeBr_3$)
- SiPMs + analogue electronics ($LaBr_3$)

Not yet measured:

- SiPMs + GET
- Scintillators in B-field

Material	Dimensions	Shape	SiPMs	GET	Osprey	Manufacturers
LaBr3	1.5"×1.5"	cylinder		3.1%	2.8%	2.6%
LaBr3	2.0"×2.0"	cube	4.2%			
CeBr3	1.5"×1.5"	cylinder		5.7%	4.2%	4.0%
CeBr3	2.0"×2.0"	cylinder		5.5%	4.5%	4.0%

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LaBr3

Dimensions	Shape	SiPMs	GET	Osprey	Manufacturers
1.5"×1.5"	cylinder		3,1%	2,8%	2,6%
2.0"×2.0"x2.0"	cube	4,2%			

Projection: SiPMs with GET	FWHM (at 662 keV)
4,7 %	31
5,0 %	33

Measurements

Estimates

CeBr3

Dimensions	Shape	SiPMs	GET	Osprey	Manufacturers
1.5"×1.5"	cylinder		5,7%	4,2%	4,0%
2.0"×2.0"	cylinder		5,5%	4,5%	4,0%
2.0"×2.0"x2.0"	cube - proj	5,2%			

Projection: SiPMs with GET	FWHM (at 662 keV)
7,1 %	47
7,4 %	49

Measurements

Estimates

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LaBr3

Dimensions	Shape	SiPMs	GET	Osprey	Manufacturers
1.5"×1.5"	cylinder		3,1%	2,8%	2,6%
2.0"×2.0"x2.0"	cube	4,2%			

Projection: SiPMs with GET	FWHM (at 662 keV)
4,7 %	31
5,0 %	33
& in magnetic field:	
5,6 %	37
6,0 %	40

Measurements
Estimates

CeBr3

Dimensions	Shape	SiPMs	GET	Osprey	Manufacturers
1.5"×1.5"	cylinder		5,7%	4,2%	4,0%
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2.0"×2.0"x2.0"	cube - proj	5,2%			

Projection: SiPMs with GET	FWHM (at 662 keV)
7,1 %	47
7,4 %	49
& in magnetic field:	
8,5 %	56
8,9 %	59

Measurements
Estimates

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LaBr3

Dimensions	Shape	SiPMs	GET	Osprey	Manufacturers
1.5"×1.5"	cylinder		3,1%	2,8%	2,6%
2.0"×2.0"x2.0"	cube	4,2%			

Projection: SiPMs with GET	FWHM (at 662 keV)	
4,7 %	31	Measurements
5,0 %	33	Estimates
& in magnetic field:		
5,6 %	37	
6,0 %	40	

CeBr3

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1.5"×1.5"	cylinder		5,7%	4,2%	4,0%
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2.0"×2.0"x2.0"	cube - proj	5,2%			

Projection: SiPMs with GET	FWHM (at 662 keV)	
7,1 %	47	Measurements
7,4 %	49	Estimates
& in magnetic field:		
8,5 %	56	
8,9 %	59	

- Two options: - Crystal + SiPM with mu-metal shield
  - Crystal via light guide to PMT (outside solenoid)
- Doppler broadening also to be factored in

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Acknowledgement:

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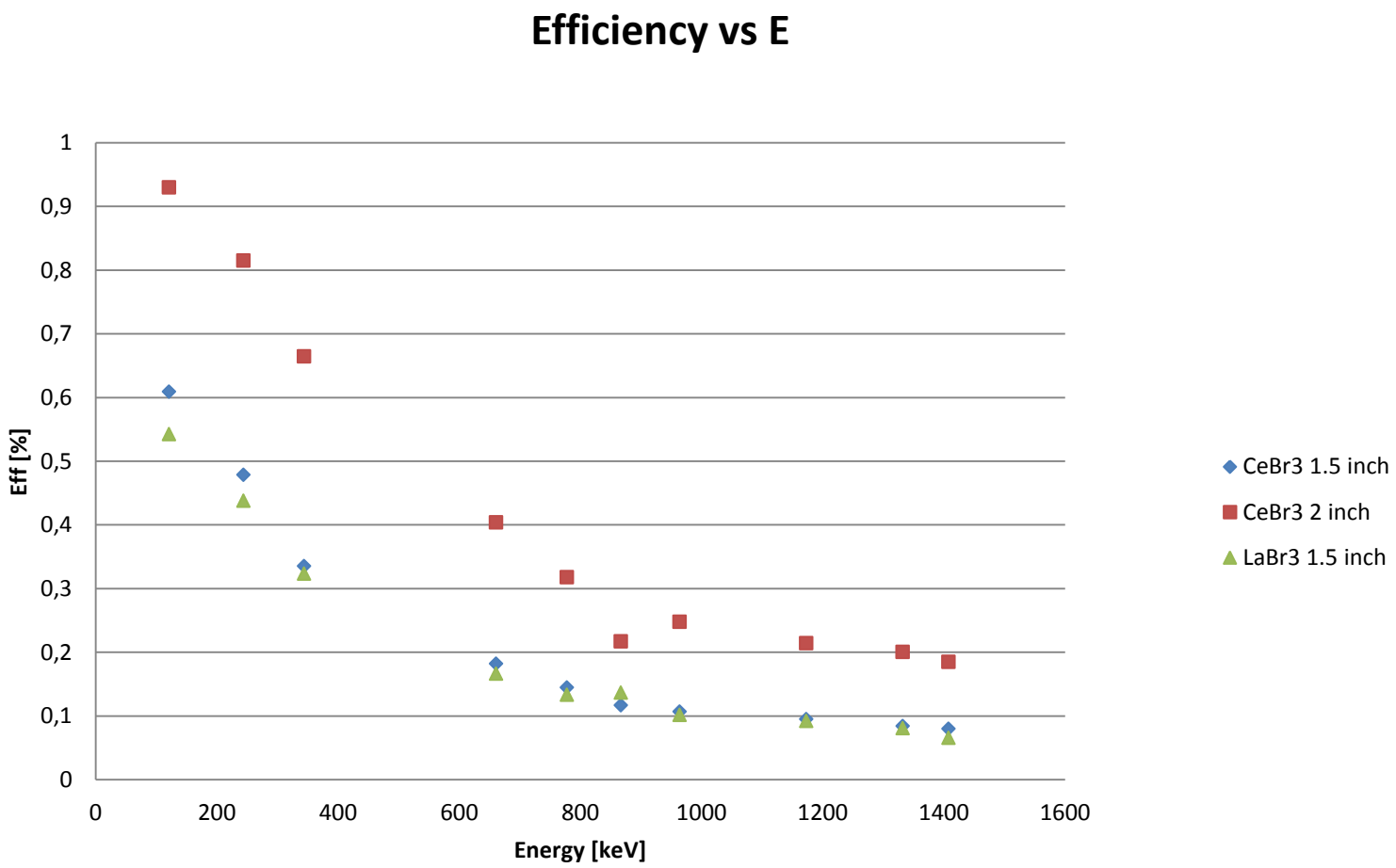
Efficiency measurements with cylindrical scintillators + PMTs



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Preliminary data

Best resolution values with GET vs nominal values

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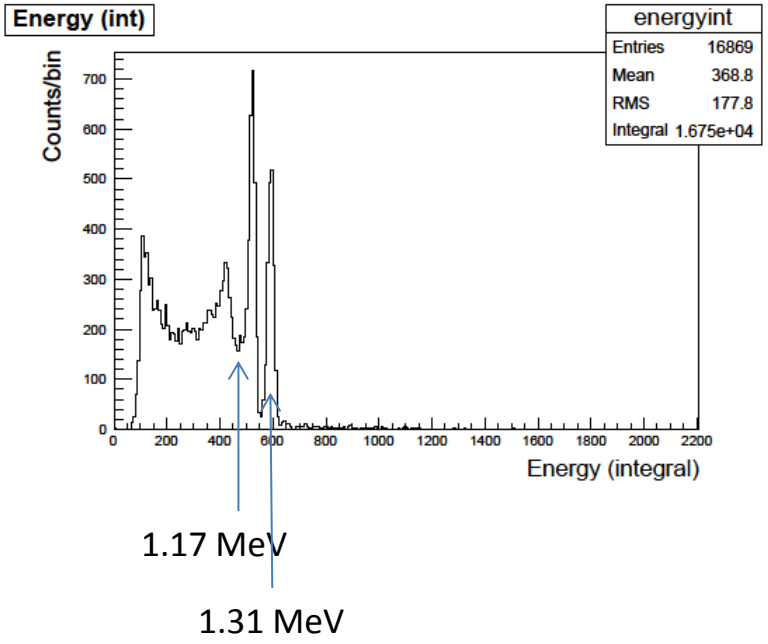
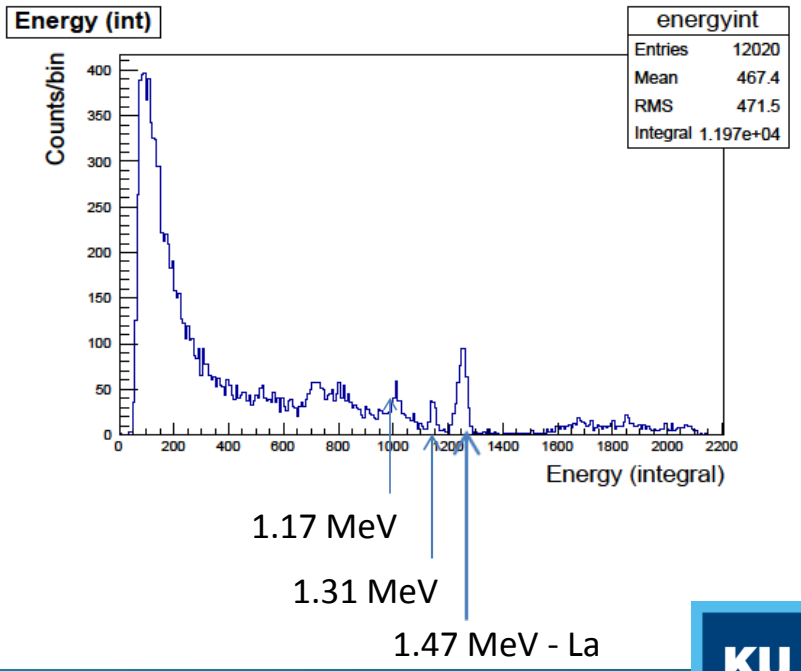
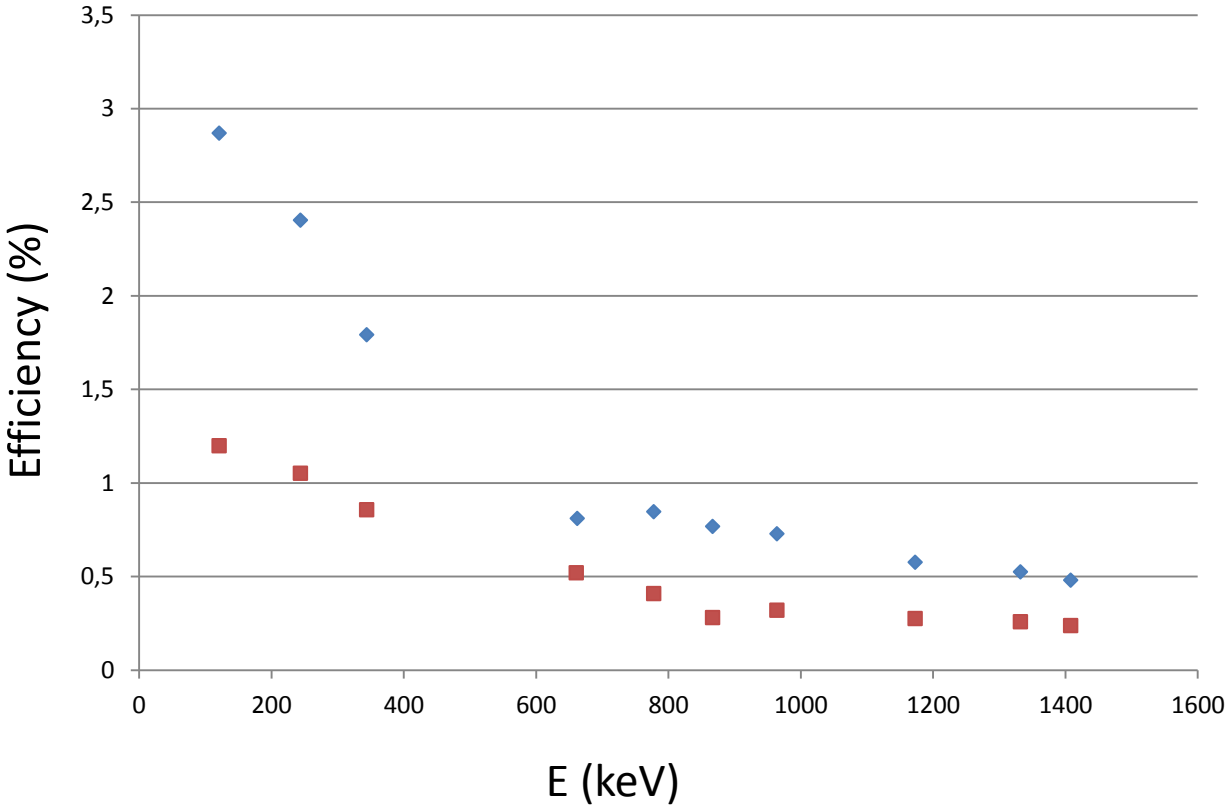
CeBr3	2"x2"	5.5%	4.0%





Efficiency measurements with cylindrical scintillators + PMTs



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